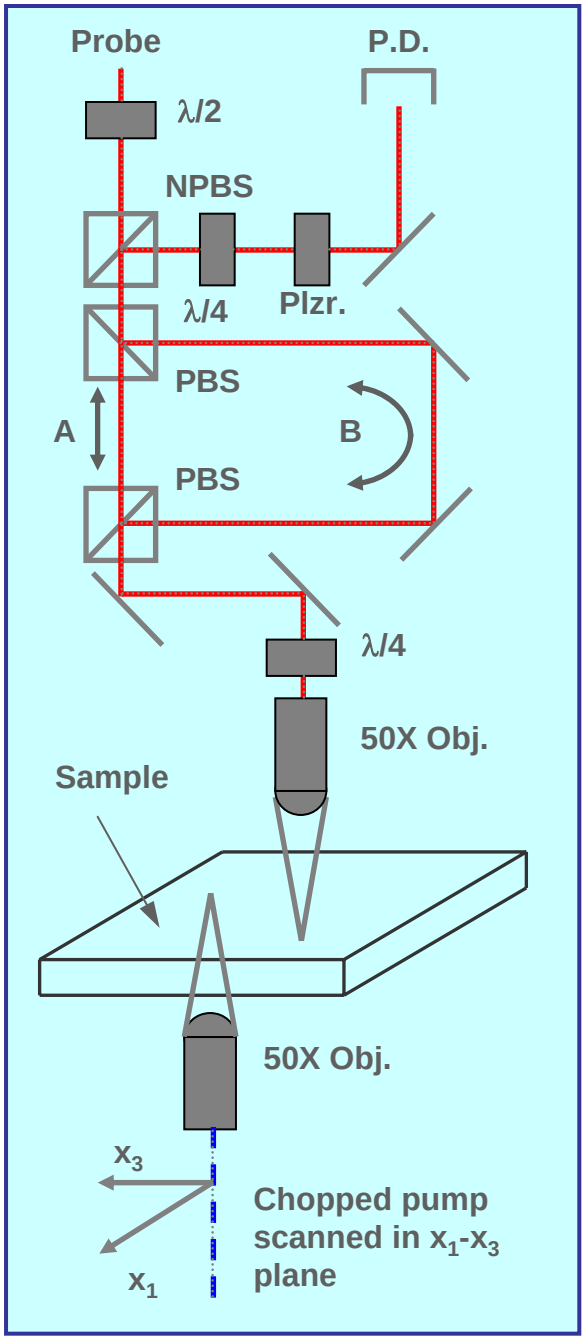
Idaho National Laboratory

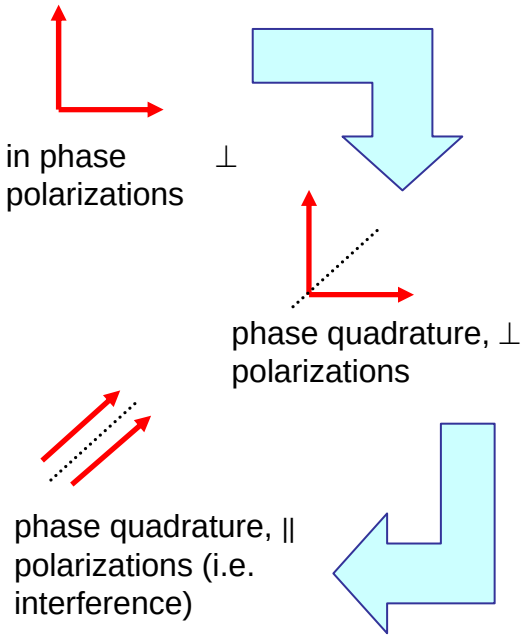
Sagnac Interferometer

Experimental setup



We use a common path Sagnac interferometer to look at ultrafast changes in optical phase. This interferometer is ideally suited to be used in the probe arm of a typical pump/probe experiment. At INL we use this interferometer to image the surface displacement caused by laser generated acoustic waves and thermal waves.

Phase demodulation with a λ/4 and a polarizer



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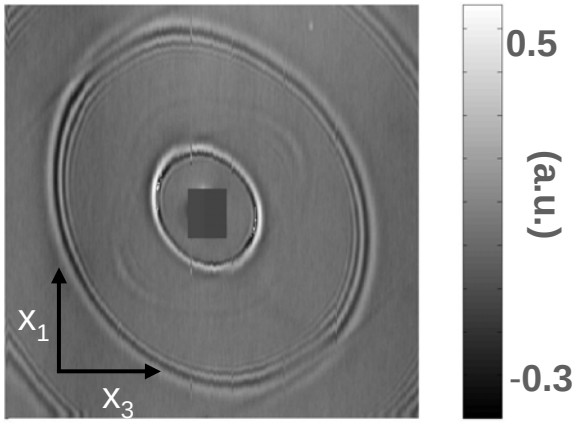
Application: Surface Acoustic Wave Imaging

Experiment



160 μm × 160 μm

Interferometric image of variations in lockin amplitude caused by surface acoustic and bulk waves propagation.

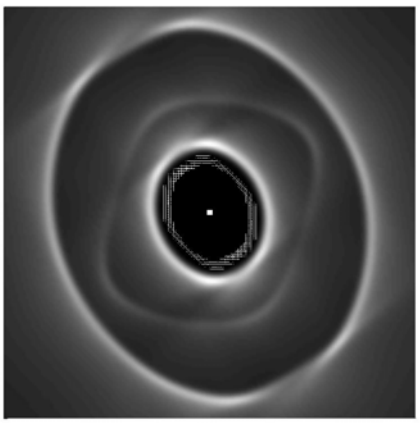
Sample specification

- 200 nm polycrystalline chromium film
- Single crystal quartz substrate (trigonal symmetry)
- C-axis coincides with x_1 axis and hexagonal edge coincides with x_2 axis
- Projection of stiffness tensor onto laboratory reference all components are non-zero

Observations

- The model accounts for acoustic diffraction from a point laser source by using an angular spectrum of plane waves.
- The results for the SAW and surface skimming bulk wave agree closely with experiment, both in amplitude and shape.
- These images lack symmetry in the x_1 and x_2 directions, revealing the rich character of the 4^{th} ranked elastic tensor in comparison to the 2^{nd} rank thermal conductivity tensor.

Theory



160 μm × 160 μm

Image derived from theory using an angular spectrum of plane waves.

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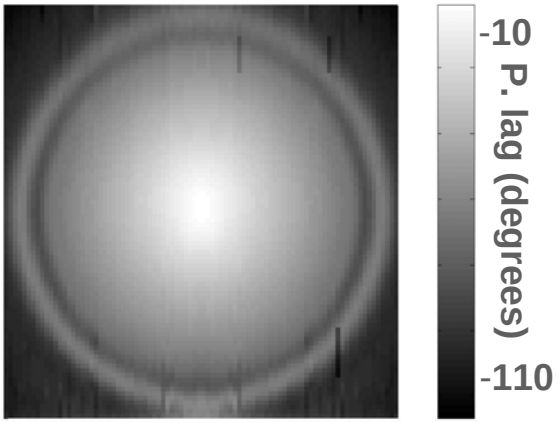
Application: Simultaneous Imaging of Elastic and Thermal Properties

Phase contour



23 μm × 23μm

Interferometric image of variations in lockin phase caused by thermal (interior) and surface acoustic waves (halo).

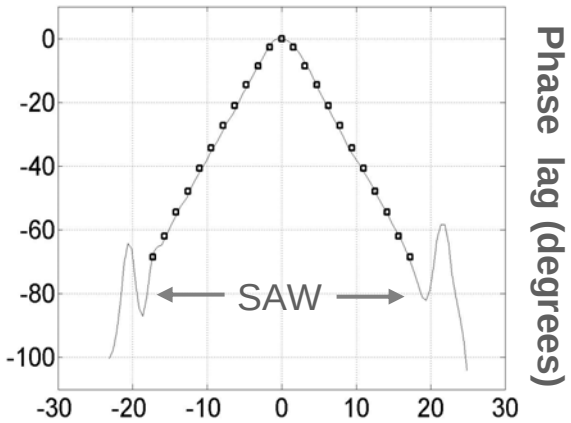
Observations

- A cross section of the phase image clearly reveals the SAW and thermal wave components.
- The linear variation near the center corresponds to the thermal wave signal.
- The rapid variation in the phase signal at approximately 20 μm (halo around the outside of the phase contour) is related to the SAW.

Observations

- For a 3 kHz modulation frequency, the thermal wave signal dominates the SAW signal. However, by monitoring the lockin phase, instead of the lockin amplitude, both signals can be imaged with comparable contrast.
- The sample in this case consisted of a 200 nm chromium film on a fused silica substrate (thermal and elastic isotropy).

Phase profile



Cross section of phase data. The linear variation near the center relates to the thermal wave and the rapid variation near the edge relates to the surface acoustic wave

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